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Book of Abstracts
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Kellie Ann Beall, Editor

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TRANSIENT AGENT, RECIRCULATING POOL FIRE (TARPF) SUPPRESSION SCREEN[1]

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The amount of a gaseous agent required to extinguish fires in full-scale engine nacelle tests varies greatly with the geometry of the fixture and the manner in which the flame is stabilized. It has been observed that if the test is designed to allow fuel to collect behind obstacles in the vicinity of a hot surface, a significantly higher mass of agent is necessary for sustained suppression. The superior performance of chemically acting agents such as CF_3Br and CF_3I relative to a hydrofluorocarbon alternative like HFC-125 is also accentuated in some of these tests. Full-scale testing carried out by the Navy using two different fixtures, each meant to simulate fires in the F/A-18 engine nacelle, has led to different conclusions regarding the amount and relative performance of both HFC-125 and solid propellant gas generator (SPGG) fire suppressants.

The complexity and unpredictability of full-scale tests can be traced to two factors: flame stabilization, and agent mixing. Flame stability is governed by local geometry, surface temperature, and fuel and air flow patterns. Flame extinction will occur if the agent is entrained into the flame zone in sufficient concentration, if the fuel and air flows are disrupted enough by the agent discharge process, or by a combination of the two effects. Entrainment and localized flame stretch are, in turn, controlled by the way the fire suppression system is designed and by the location of the fire relative to the discharge nozzle.

Hirst and Sutton [1] developed a wind tunnel to explore the impact of step height, air flow, and pressure on the blow-out of a jet fuel pool fire stabilized behind a backward facing step. Hirst et al. [2] studied the suppression of these types of fires using various halons, and concluded that a liquid pool burning in a flow behind an obstacle is the most difficult fire to extinguish. This was born out in full-scale tests done later [3]. Experiments by Hamins et al. [4], in cooperation with Walter-Kidde Aerospace, were conducted in a wind tunnel scaled down from the earlier work by Hirst to examine the performance of HFC-125 and HFC-227ea. Research is currently underway at the Air Force Research Laboratory [5] to identify the detailed structure of a flame stabilized by an obstruction in a 0.15 m cross-section laboratory wind tunnel. They are measuring the velocity field and OH levels for a methane pool fire with obstructions of various geometry.

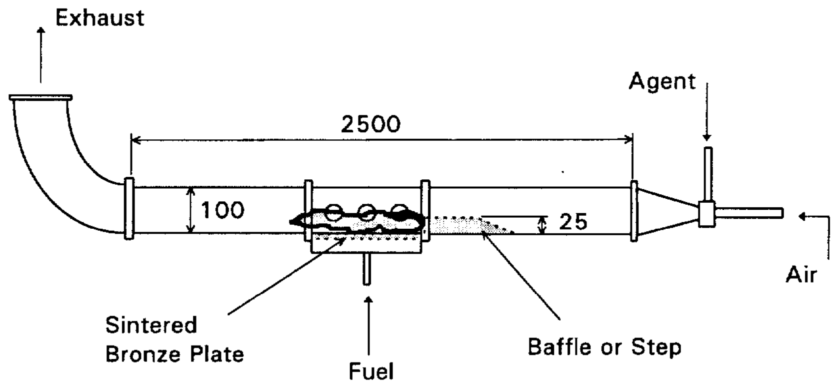
The turbulent spray burner was designed [6] to simulate an engine nacelle spray fire resulting from a ruptured fuel line. This apparatus provides better control of the agent discharge and mixing process than the baffle-stabilized fire test fixtures described above, and can better simulate the discharge of an SPGG with less disruption to the incoming air. The turbulent spray burner can be used with both gaseous and powdered agents. Hamins et al. [4] redesigned the burner to include a heated disk in the center of the flow downstream of the fuel nozzle. They showed that the concentration of nitrogen necessary to extinguish a turbulent propane flame increased substantially with surface temperature. The same trend, but to a lesser degree, was observed with HFCs.

The transient agent, recirculating pool fire (TARPF) suppression screen extends the capabilities of the turbulent spray burner, and combines with it the desirable attributes of the baffle-stabilized pool fire test facility. That is, it reproduces the most difficult fire situation and allows control of critical agent discharge parameters, including discharge rate, duration and air flow. The performance of powders and gases can be examined, and the relation between the suppression duration and the temperature and location of a hot surface can be explored.

The ability to determine the relative effectiveness of alternative agents is key to the development of new fire suppression systems. The Next Generation Program (NGP) has the goal of identifying agents that are as effective as CF_3Br in suppressing fires in spaces currently protected with the halon. The physical and chemical properties, and the manner of storage and release, of these next generation suppression systems may be quite unlike halon, but their effectiveness must be bench-marked against CF_3Br. The TARPF facility will provide the means to screen new concepts in the laboratory for applications in engine nacelles and other spaces involving baffle-stabilized pool fires with adjacent hot surfaces.

[1] Supported by Next Generation Program, through SERDP

Schematic diagram of the Transient Agent Recirculating Pool Fire (TARPF) suppression screen



A sketch of the TARPF flow tunnel is shown in the figure. The main portion is about 2.5 m long with a square cross-section 92 mm on a side. Air, supplied by a compressor rated for a maximum flow of about 180 g/s at 1.0 MPa, can be delivered to the tunnel at nominal speeds up to 16 m/s. A heater is available to increase the inlet air temperature to above 200 °C. A porous bronze burner, 92 mm wide by 190 mm long, is located on thefloor of the tunnel test section. Propane is the current fuel, but plans include the capability to burn JP-8. Heat release rates up to about 20 kW are anticipated. A stainless steel baffle, 25 mm high, is located upstream of the burner. A ramp can also be inserted to form a backward-facing step. An electric strip heater about 25 mm by 87 mm is designed to simulate a hot surface reignition point, and should produce average surface temperatures up to 650 °C. It can be placed in the air flow either ahead of or behind the burner, at a position where the JP-8 can be sure to impinge.

The agent is injected downstream of the air metering orifice. Since the flow is choked in the metering orifice plate, the introduction of the agent can be accomplished without altering the total air flow. Mixing of the agent with the air is facilitated by injecting the agent radially from opposite directions into the reduced diameter entrance region. The distance between the injection ports and the pool fire, about one meter, is a compromise between the desire for uniform mixing in the cross-stream direction and plug flow in the stream-wise direction. A pressure vessel is used to store the gaseous agent to be tested. The discharge rate and duration are controlled by the initial agent pressure and an electronically actuated solenoid valve. Powders with physical properties similar to sodium bicarbonate will be injected by pressurizing the vessel with nitrogen and entraining a measured amount of the powder placed in a tee at the entrance to the injection port, as done previously in the turbulent spray burner. The TARPF facility is designed to handle new propellant formulations for SPGG suppressants in quantities of about one gram. It may be possible to evaluate SPGGs of considerably higher mass (if safety can be assured) by designing a pre-discharge chamber to handle the bulk of the effluent, and bleeding a small amount of the combustion products (including particulate) into the tunnel.

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